PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: ROBERT GEORGE FELLER and JOHN JOSEPH SWEENEY

870,583

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CORRECTION OF CLERICAL ERROR/S

SPECIFICATION NO. 870,583

The following correction is in accordance with the Decision of the Assistant Comptroller acting for the Comptroller-General, dated the 5th day of September, 1962.

Page 1, line 4, *delete* "New Jersey" *insert* "the State of Delaware"

THE PATENT OFFICE,
2nd October, 1962

DS 68306/1(22)/R.109 200 9/62 PL

of insulated electric cables capable of continuous operation at temperatures up to 200° C. and of insulated electric cables capable of carrying intermittent pulses of energy of short duration, hereinafter called " pulse cables ".

One aim of the invention is to reduce to a minimum corona discharge between the cable conductor and its insulation.

According to this invention the method of manufacturing such a cable comprises applying to the cable conductor an enclosing layer of a semi-conducting silicone-base composition (containing carbon black or like conducting material) and including a suitable peroxide curing agent, such layer being partially cured, either before or after application to the conductor; applying to such partially cured layer an enclosing, insulating wall of the same silicone-base composition (without the carbon black or like content) including the same or a like peroxide curing agent; and completing the curing of the semi-conducting layer and insulating wall *in situ*.

The inner semi-conducting layer, viz., the layer immediately surrounding the cable conductor, may be applied to the conductor in the form of a tape, or it may be extruded directly upon the conductor, but in either case it must be partially cured before the application of the insulating wall. Where the semi-conducting layer is applied to the conductor as a tape, it must be partially cured not only before the application of the insulating wall extruded upon the conductor, it will be appreciated that the completion of curing is done *in situ*.

In some types of cables, for instance " pulse " cables, not only is a semi-conducting layer employed beneath the insulation, but a semi-conducting silicone adherent layer is applied upon the exterior of the insulating wall as well. In such a cable the procedure is the same as already described, so far as application of the inner layer and of the insulating wall is concerned, but the inner layer and insulating wall are only partially cured before the application of the outer semi-conducting layer. The outer layer may take the form of a tape, in which case it is partially cured before its application to the partially cured insulating wall, and curing of both layers and of the insulating wall is carried to completion *in situ*. On the other hand, if the outer layer is extruded directly upon the partially cured insulating wall, then the completion of the curing of the partially cured inner layer and insulating wall and curing of the hitherto uncured outer layer *in situ* are effected in a single final operation.

Semi-conducting mixtures employing various types of silicones as a base essentially contain large amounts of conducting black, the presence of which inhibits curing of these mixtures by peroxide-curing systems normally used in the curing of silicone insulating compounds. Accordingly, an attempt was made

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International Classification:—H01b. C08g.

COMPLETE SPECIFICATION

Method of Making Electric Cables

We, THE OKONITE COMPANY, of 220, Passaic Street, Passaic, New Jersey, United States of America, a Corporation organised under the Laws of New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the manufacture of insulated electric cables capable of continuous operation at temperatures up to 200° C. and of insulated electric cables capable of carrying intermittent pulses of energy of short duration, hereinafter called "pulse cables".

One aim of the invention is to reduce to a minimum corona discharge between the cable conductor and its insulation.

According to this invention the method of manufacturing such a cable comprises applying to the cable conductor an enclosing layer of a semi-conducting silicone-base composition (containing carbon black or like conducting material) and including a suitable peroxide curing agent, such layer being partially cured, either before or after application to the conductor; applying to such partially cured layer an enclosing, insulating wall of the same silicone-base composition (without the carbon black or like content) including the same or a like peroxide curing agent; and completing the curing of the semi-conducting layer and insulating wall *in situ*.

The inner semi-conducting layer, viz., the layer immediately surrounding the cable conductor, may be applied to the conductor in the form of a tape, or it may be extruded directly upon the conductor, but in either case it must be partially cured before the application of the insulating wall. Where the semi-conducting layer is applied to the conductor as a tape, it must be partially cured not only before the application of the insulating wall but before the tape is applied to the conductor. If, on the other hand, the semi-conducting layer is extruded directly about the conductor, it must be partially cured after extrusion and before the application of the insulating wall.

When employing tape as the inner layer, completion of the curing of this layer and the entire cure of the insulating wall is effected *in situ*. Where the inner layer is extruded upon the conductor, it will be appreciated that the completion of curing is done *in situ*.

In some types of cables, for instance "pulse" cables, not only is a semi-conducting layer employed beneath the insulation, but a semi-conducting silicone adherent layer is applied upon the exterior of the insulating wall as well. In such a cable the procedure is the same as already described, so far as application of the inner layer and of the insulating wall is concerned, but the inner layer and insulating wall are only partially cured before the application of the outer semi-conducting layer. The outer layer may take the form of a tape, in which case it is partially cured before its application to the partially cured insulating wall, and curing of both layers and of the insulating wall is carried to completion *in situ*. On the other hand, if the outer layer is extruded directly upon the partially cured insulating wall, then the completion of the curing of the partially cured inner layer and insulating wall and curing of the hitherto uncured outer layer *in situ* are effected in a single final operation.

Semi-conducting mixtures employing various types of silicones as a base essentially contain large amounts of conducting black, the presence of which inhibits curing of these mixtures by peroxide-curing systems normally used in the curing of silicone insulating compounds. Accordingly, an attempt was made

to produce a cable employing a sulphur-curing, semi-conducting silicone mixture for the semi-conducting layer. While such a material cured satisfactorily, it was found that the presence of such material, either uncured or precured, adjacent an insulating wall of normal peroxide-curing silicone resulted in complete inhibition of cure of the insulating wall.

Also an attempt was made to produce a cable employing a di-tertiary butyl peroxide-curing, semi-conducting composition based on silicone gum having a low mole percentage of vinyl methyl siloxane groups. This semi-conducting compound cured very well, but, when placed either in the cured or uncured state adjacent an insulating wall made of different silicone composition from that of the semi-conducting layer, viz. benzoyl peroxide-curing silicone, the result was severe inhibition of cure of the insulating wall.

A cable having satisfactory physical, electrical, and ageing characteristics can be successfully produced by employing, as a base for the semi-conducting material and the insulating composition, a gum having a low mole percentage of vinyl methyl siloxane groups, for example a dimethyl siloxane gum containing small amounts of vinyl siloxanes, in which the vinyl/silicon ratio is between 1:1350 and 1:340, as manufactured and sold under the Trade Mark "W.96" by the Silicone Division of Union Carbide and Carbon Corporation; and by curing both the semi-conducting material and the insulating composition with di-tertiary butyl peroxide or di-cumyl peroxide or by curing the semi-conducting material with di-tertiary butyl peroxide and the insulating compound with di-cumyl peroxide or *vice versa*.

For achieving maximum conductivity, so far as the semi-conducting material is concerned, acetylene black has been found the most effective.

In the accompanying drawings, which illustrate by way of example only, two embodiments of the invention,

Figure 1 shows in elevation a cable embodying the invention; and

Figure 2 is a similar view showing another embodiment of the invention.

Referring to Figure 1 of the drawings, 2 designates the cable conductor. Immediately about this conductor is a semi-conducting adherent layer 4 enclosed in an adherent insulating wall 6. A metal shield or outer conductor has been designated 8.

The cable is sheathed or jacketed in a sheath or jacket 10 of any of the materials conventionally employed for this purpose in the electric cable industry.

The semi-conducting layer 4 is made from a mixture comprising the following ingredients:—

	Parts by weight
Vinyl-containing silicone gum	100
Acetylene black - - -	40—70
Di-tertiary butyl peroxide or di-cumyl peroxide - -	4— 8

It will be appreciated that the amount of acetylene black employed depends upon the desired conductivity in the finished product, —hence, the range of from forty to seventy parts by weight above set out. In practice, compounds having volume-resistivities lower than 1 ohm-cm. have been obtained and used in manufacture. The wide range set out of di-tertiary butyl peroxide or di-cumyl peroxide is to compensate for evaporation losses prior to cure.

In practice, the above compound may be calendered to a selected width and thickness, partially cured by exposure in air for one minute at 450° F., and then wrapped as a tape about the cable conductor 2 to provide an adherent semi-conducting layer.

The insulating wall 6 is made from a mixture comprising the following ingredients:—

	Parts by weight
Vinyl-containing silicone gum	100
Silica - - - - - -	30—120
Di-tertiary butyl peroxide or di-cumyl peroxide - -	1— 3

The amount of silica used will depend mainly on the physical and electrical properties desired and on the type of silica employed.

The above mixture may be extruded about the semi-conducting layer 4. The assembly is then subjected to a curing action, completely to cure the insulation and to complete the curing of the semi-conducting layer *in situ*.

The semi-conducting compound composing the layer 4 may be extruded directly about the conductor 2 and then subjected to the action of air for one minute at 450° F. The insulating compound composing the wall 6 is then extruded about the layer 4, after which the insulating compound is cured and curing of the layer 4 completed *in situ*.

As previously noted, in some types of electric cable it is necessary to provide a semi-conducting layer over the insulating wall, and such a cable has been shown in Fig. 2.

Referring to this view, 12 designates the cable conductor. To this conductor a semi-conducting layer 14 is applied, the ingredients of which are the same as those of the semi-conducting layer 4 of Fig. 1. This compound may be extruded directly upon the conductor, after which it is partially cured by exposure in air for one minute at 450° F. Immediately about the semi-conducting layer 14 an insulating wall 16 is extruded. The ingredients of this wall are the same as those of the insulating wall 6 of

Fig. 1, and after this wall has been applied, a further cure f the semi-conducting layer and a partial cure of the insulating wall 16 are effected.

Over the partially cured insulating wall 16 a semi-conducting layer 18 is extruded, the ingredients of which are the same as those of semi-conducting layer 14. The assembly is then subjected to a curing action, completely to cure the outer semi-conducting layer 18 and to complete the cure of the underlying insulating wall 16 and the inner semi-conducting layer 14.

19 designates a metal shield or outer conductor, corresponding to the shield or outer conductor 8 of Fig. 1, and 20 designates the outer jacket or sheath.

The outer semi-conducting layer 18 may be applied in partially cured tape form to the partially cured insulating wall 16. In that event, the mixture which is to compose the layer 18 is calendered to a selected width and thickness and then partially cured by exposure in air at a temperature of around 450° F. It is then wrapped around the insulating wall 16 and the assembly subjected to a curing action to complete the curing of the two semi-conducting layers 14 and 18 and of the insulating wall 16 *in situ*.

WHAT WE CLAIM IS:—

1. The method of manufacturing an electric cable comprising applying to the cable conductor an enclosing layer of a semi-conducting silicone-base composition (containing carbon black or like conducting material) and including a suitable peroxide curing agent, such layer being partially cured, either before or after application to the conductor; applying to such partially cured layer an enclosing insulating wall of the same silicone-base composition (without the carbon black or like content) including the same or a like peroxide curing agent; and completing the curing of the semi-conducting layer and insulating wall *in situ*.

2. A modification of the method claimed in Claim 1, in which the *in situ* curing of the insulating wall and semi-conducting layer is not finally completed; and an additional semi-conducting layer of silicone-base composition including the same or a like peroxide curing agent to that of the insulating wall is applied over the latter, either uncured or partially cured; and the curing of the insulating wall and of both semi-conducting layers is then completed.

3. The method claimed in Claim 1 or Claim 2, in which the peroxide curing agent incorporated in the semi-conducting layer, or either of them, or in the insulating wall, is either di-tertiary butyl peroxide or di-cumyl peroxide.

4. The method claimed in any preceding claim, in which the silicone-base composition is a vinyl containing silicone gum.

5. The method claimed in Claim 4, in which the silicone-base composition is a gum having a low mole percentage of vinyl methyl siloxane groups.

6. An electric cable made by a method as claimed in any preceding claim.

7. An electric cable constructed substantially as herein described with reference to Figure 1 or Figure 2 of the accompanying drawings.

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870583 COMPLETE SPECIFICATION
1 SHEET This drawing is a reproduction of the Original on a reduced scale

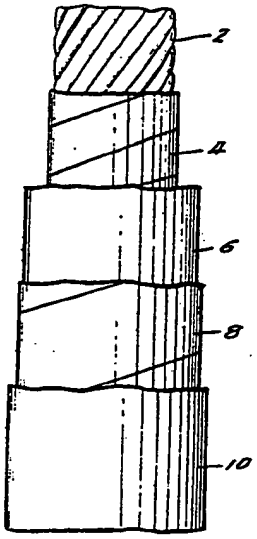

FIG. 1

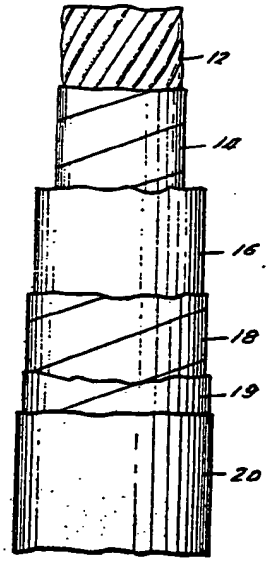

FIG. 2